BASIC SCIENCE SERIES

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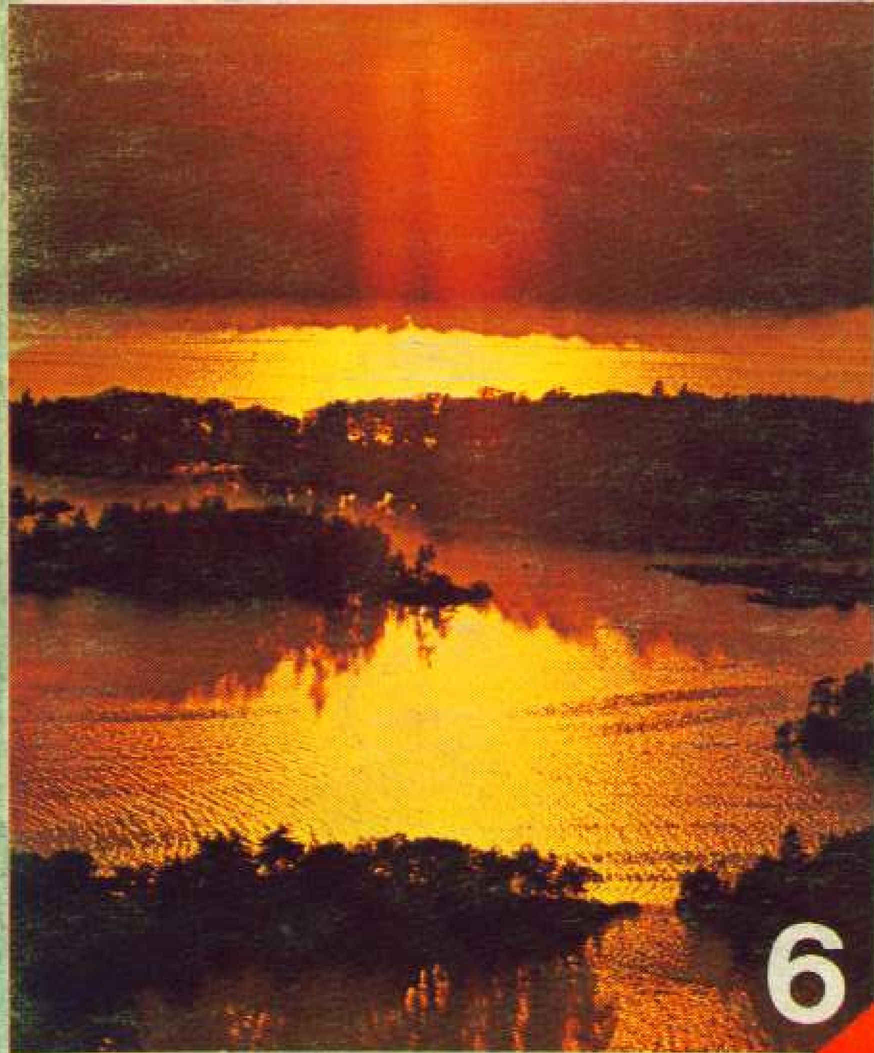

6

LIGHT

REVISED EDITION

BASIC SCIENCE SERIES — BOOK 6

REVISED EDITION

LIGHT

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PREFACE

In the present technological era it is important that all children should be given a basic training in scientific knowledge. The Basic Science Series is written with this aim in mind.

The series includes 16 scientific topics each of which is a complete information book. In its entirety the scheme covers the syllabus generally adopted by upper primary classes and lower secondary forms.

The text is supported by attractive illustrations and is written in a style acceptable to a wide range of pupils.

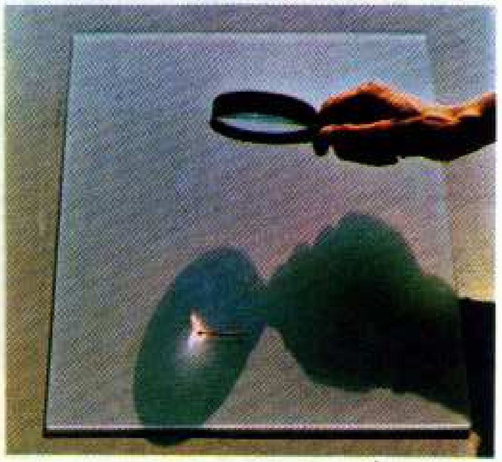
A strong feature of each of the books is the inclusion of many simple experiments under the section "Things to Do". This encourages the pupil to keep his own project book and ultimately assists his understanding of Science.

CONTENTS

INTRODUCTION

Blindfold yourself and try to move around in the classroom. Will you be able to do this? You will probably fall over a chair or walk into the wall. You feel helpless when you try to move about in the dark. Now do you see how important light is? Close your eyes and think about what it would be like to live in a world where there is no light.

With the help of a magnifying glass you can make use of light from the sun to light a match or burn a piece of paper. This shows that light is a form of **energy**.



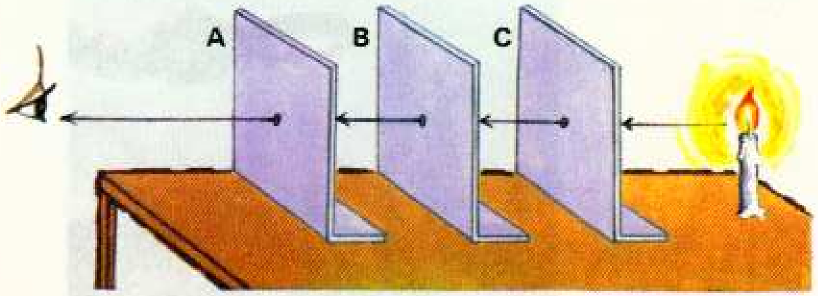
Light is a form of energy.

HOW LIGHT TRAVELS

How does light travel? Does it travel in a straight line? Or does it travel like water, flowing around objects blocking its path? We can find this out very easily.

Things to Do

Cut three pieces of cardboard A, B and C. Each piece should be about 25 cm square. Draw diagonals on each of the square cardboards. At the point where the diagonals on each cardboard cut, make a very small hole with a pin. Now fix each piece of cardboard on a wooden stand and place it on a table. Place the pieces as shown in the picture. Pass a string straight through the holes. Pull the string taut so that the holes are all in a straight line. Place a lighted candle



To show that light travels in a straight line

near the hole in cardboard C. Look through the hole in cardboard A. Can you see the candle-light?

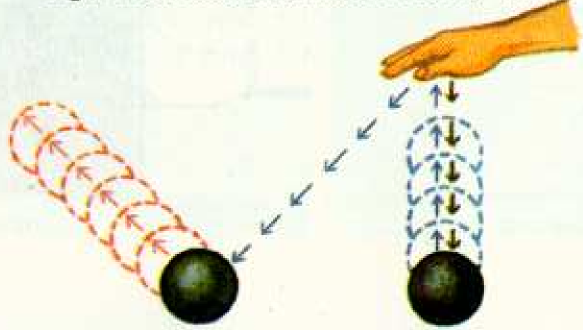
Move cardboard A so that its hole is not in line with those of B and C. Again, look through the hole at A. Can you see the light of the candle? Why? This shows that light travels in a straight line. When the three holes were in line, light passed through them to your eye. When the holes were not in line, light passing through the hole in C could go through the hole in B. But this light could not bend to go through the hole in A.

HOW LIGHT BEHAVES

Light travels in a straight line at 300,000,000 metres per second. It will go on travelling at this speed until something comes into its way. When this happens, part or all of the light may be **reflected**, **absorbed** or **transmitted** by the thing or **object** that comes into its way.

Throw a tennis ball on the floor. The ball

Light bounces back like a rubber ball.

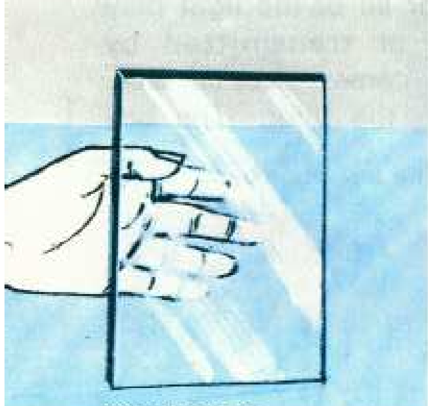


bounces back. In the same way, when light falls on certain things it bounces back. When this happens, the light is said to be **reflected**. This can be clearly shown when you shine a beam of light from a torch at a mirror in a dark room.

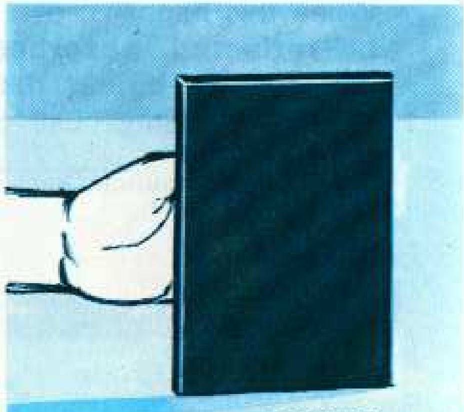
Some objects do not allow light to go through them. If light is not completely reflected by the object, some light is said to be **absorbed**. Things that do not allow light to pass through are said to be **opaque**.

If light goes right through an object, the light is said to be **transmitted**. Objects which transmit light are said to be **transparent**. Glass is transparent. Do you know of other transparent objects?

You have learned that light can travel through air. Now let us see whether it can travel through water.



transparent



opaque

Things to Do

You will need a piece of cardboard with a hole in the centre. The hole should be large enough for a pencil to go through. Next, with a mirror, reflect sunlight in such a way that the sunlight goes through the hole in the cardboard. Let the spot of sunlight fall on a book, on the wall, on the ground or on your clothes.

Look at the spot of sunlight. The sunlight first fell on the mirror. The mirror reflected the sunlight which passed through the hole in the cardboard. It fell on your book as a spot of sunlight.

Now place a jar of clear water between the cardboard and the spot of sunlight. Can the sunlight pass through the jar of water? Now place some chalk dust in the jar of water so that the water turns chalky. Can the sunlight pass through the chalky water?

SHADOWS

We can see many shadows of objects all around us. Do you know how shadows are formed? Let us find out.

Things to Do

You can do this in a dark room or you can do it at night. Place a lighted candle on a table and fix a white cardboard on

a wall about one metre away from the candle as shown in the picture. Now bring your fingers between the candle and the cardboard. Move your fingers about.

Making shadows with a candle

What do you see on the cardboard? Instead of using hands, use other opaque objects such as shapes cut out from cardboard pieces.

Hold the object in a fixed place. Move the candle nearer to and then further away from the cardboard. What happens to the shadows when you do this? Now leave the candle in a fixed position, but move the object nearer to and then further away from the cardboard. What happens?

Light from the candle falls on the cardboard. When an object is placed between the candle and the cardboard, a black shape of the object appears on the cardboard. The light from the candle falls on the object but cannot pass through it. This means that no light will fall on the cardboard and therefore that part of the cardboard looks dark. This dark shape is called a **shadow**. When the candle or object is moved the shadow becomes bigger or smaller.

COLOURS OF LIGHT

Natural light or 'white' light is actually made up of many colours. Have you seen a **rainbow**?

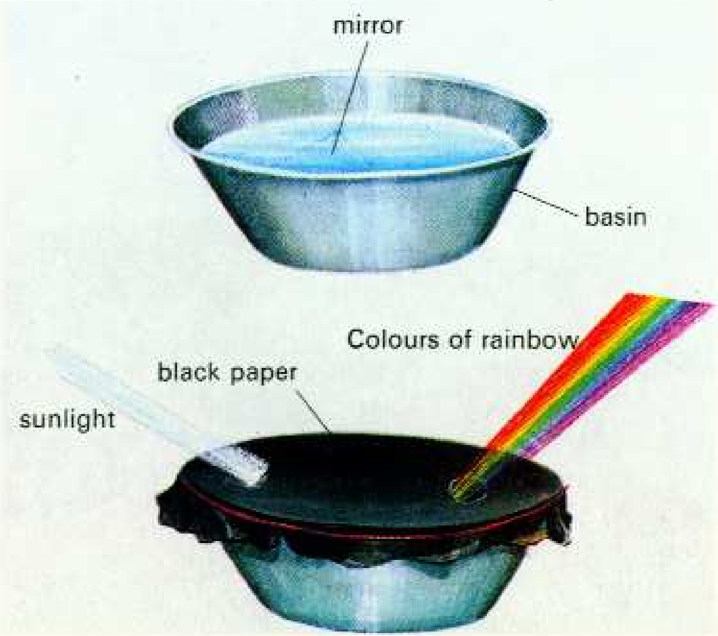
Can you see the colours of the rainbow?

We can see rainbows after a rain. They are formed when sunlight passes through small drops of water in the sky. Next time you see a rainbow, try to make out the different colours. You should be able to name seven different colours.

Things to Do

We can find out how the colours in the rainbow are formed by doing this. Pour

To find out how the colours of the rainbow are formed



some water into a basin. Cut a piece of black paper so that it can cover the top of the basin completely. Fold the round piece of black paper into half and unfold it. On one half, cut a narrow slit. On the other half, cut a round hole and paste a piece of tracing paper on the black paper to cover this hole. Do not cover the slit.

Next, place a mirror at the bottom of the basin. The silver side (the reflecting side) of the mirror must face upwards. Cover the top of the basin with the piece of black paper you have made. Hold it in place with adhesive tape or glue. Now move the basin to a place near a window where sunlight is coming in. Place the basin so that the sunlight goes into the basin through the slit. Roll another piece of black paper into the shape of a cylinder. Place this over the circular piece of tracing paper. Look through it. What do you see? Are the colours the same as those found in a rainbow?

The band of coloured lights you saw is called the **spectrum**. The seven colours are red, orange, yellow, green, blue, indigo and violet. Where do the colours of the spectrum come from? The colours are from sunlight. Therefore white light is not really white but is actually made up of the colours of the spectrum.

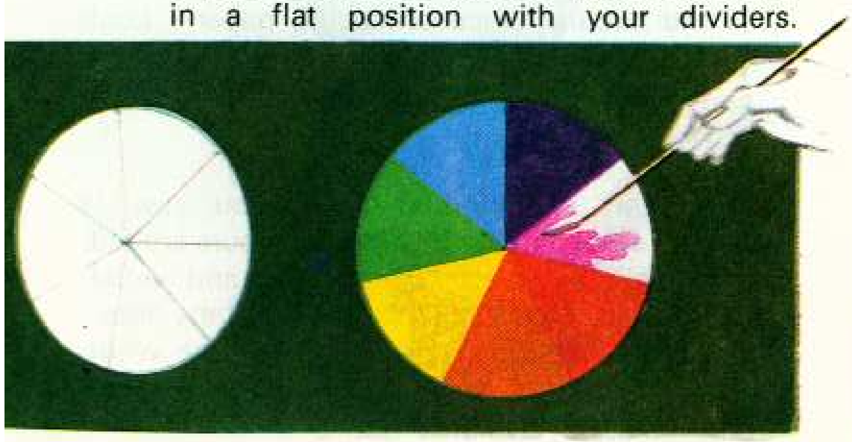
MAKING COLOURS WHITE

The colours of a rainbow can be obtained by breaking up white light. Is it possible to combine these colours into white light? We can find this out easily.

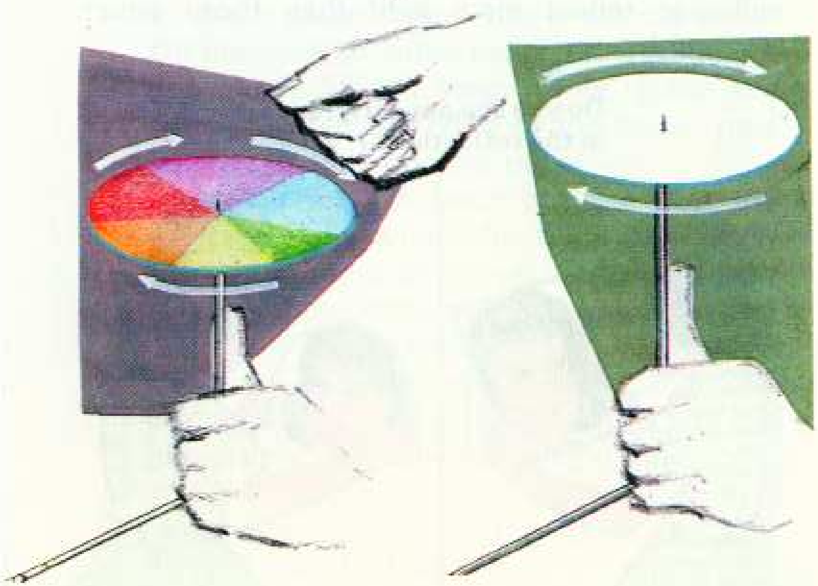
Things to Do

Get a round piece of cardboard. Cut a piece of white drawing paper of the same size. Carefully paste the piece of white drawing paper on the cardboard. Divide the circle into seven equal parts. Using water colours, paint each of the parts with one colour of the rainbow. Make sure that the colours are in the order that you see in a rainbow.

Now make a hole in the centre of the board and fit the point of one arm of a pair of dividers into it. Hold the board in a flat position with your dividers.



Spinning the cardboard



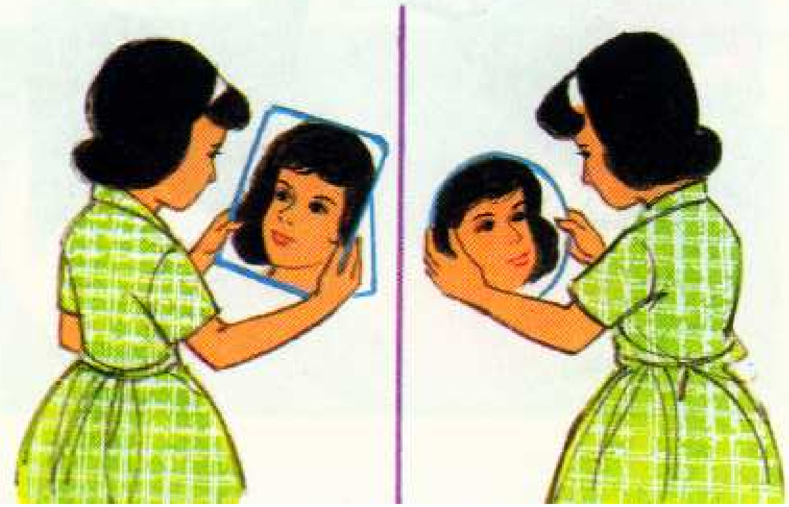
The coloured side should face upwards. Now spin the board with your other hand. Keep it spinning. What is the colour of the spinning board?

When the board was spinning slowly, you could see all the different colours. When it was spinning very fast the board looked white. You could not see any of the colours.

REFLECTION OF LIGHT

All things except those which are black reflect part or all of the light falling on them. Light-coloured things reflect more light than dark-coloured things. Things which are smooth will also reflect more light than those which are rough.

Do you see any difference in the reflections? Why?



A mirror has a smooth surface. Take it and look into it. Can you see yourself in it? Take a biscuit tin cover and look into it. Is the surface of the cover smooth? What you see on a reflecting surface is known as an **image**. Later you will find that an image can also be formed on a screen.

Things to Do

The best reflecting surface is the mirror. We shall use a mirror to find out more about reflection. We shall also need a large piece of white paper, a piece of black paper, pins, ruler, protractor and torch.

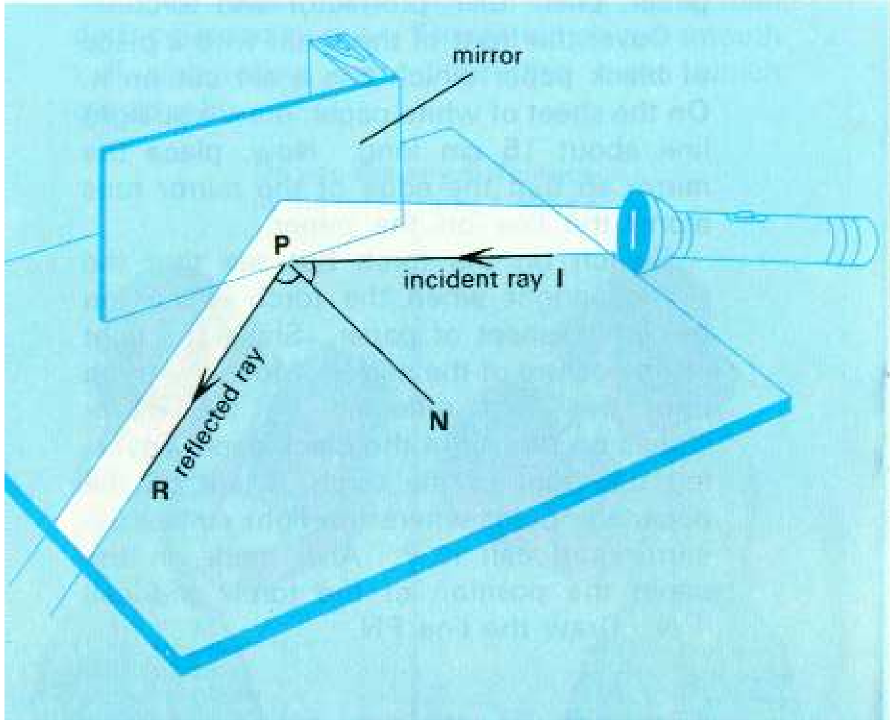
Cover the front of the torch with a piece of black paper which has a slit cut on it. On the sheet of white paper, draw a straight line about 15 cm long. Now, place the mirror so that the edge of the mirror runs along the line on the paper.

Switch on the torch but see that the slit is upright when the torch is laid on the white sheet of paper. Shine the light on the centre of the mirror. Move the torch until the light reflected by the mirror shines on the slit in the black paper covering the front of the torch. Mark on the paper the point where the light strikes the mirror and call it P. Also mark on the paper the position of the torch and call it N. Draw the line PN.

Now move the torch to the position shown in the diagram. The light now shining on P is called the **incident ray**. The light reflected from P is called the **reflected ray**. Trace the rays on the piece of paper. The angle between the incident ray and PN is called the **angle of incidence**. The angle between the reflected ray and PN is called the **angle of reflection**.

With a protractor measure the angle of incidence and the angle of reflection. What can you say about these two angles?

Reflection from a plane mirror



USES OF MIRRORS

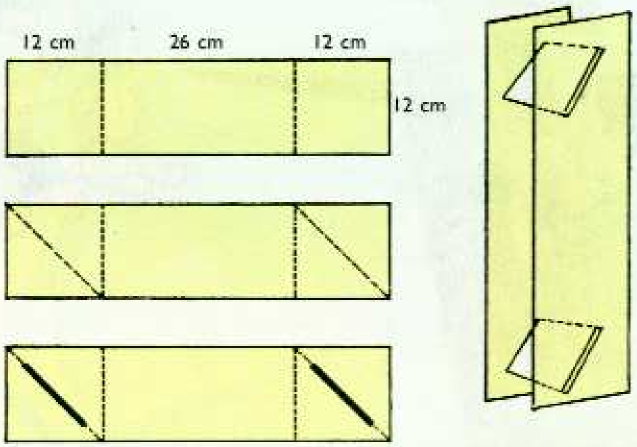
Since mirrors can reflect light and form images, they are made use of in many ways. We use mirrors to look at ourselves. Mirrors are also used for looking at things behind us. Mirrors in cars and buses are used in this way. Mirrors are also used to 'bend' light around corners. If a mirror is placed at a corner, a person can see things around the corner. Mirrors are used to bend light in a **periscope**. You can make a simple periscope by using two mirrors.

Mirrors can be used to make a periscope.

Things to Do

You will need two rectangular mirrors of the same size and two pieces of cardboard 50 cm by 12 cm. Take one of the pieces of cardboard and draw a vertical line 12 cm from each end of the cardboard. A square will then be formed at each end. Draw a diagonal in each square such that the diagonals are parallel to each other. Take a pair of scissors and carefully cut a slit along the middle of each diagonal as shown in the diagram. The slits should be slightly shorter than the width of the mirror otherwise the mirrors may fall off when they are inserted. Do the same with the other piece of cardboard.

How to make a periscope



The next step is to put the two cardboards upright near each other. Then insert one mirror in the top slits of the cardboards and the other in the bottom slits as shown in the diagram. Remember that the reflecting side of the top mirror must face downwards and that of the bottom one must face upwards. Your periscope is now ready for use.

THE EYES

We use the eyes for seeing things. The eyes are said to be the **organs of sight**.

There are other organs for hearing, smelling and tasting. The ear is the organ which is used for hearing. The nose is used for smelling. The tongue is used for tasting.

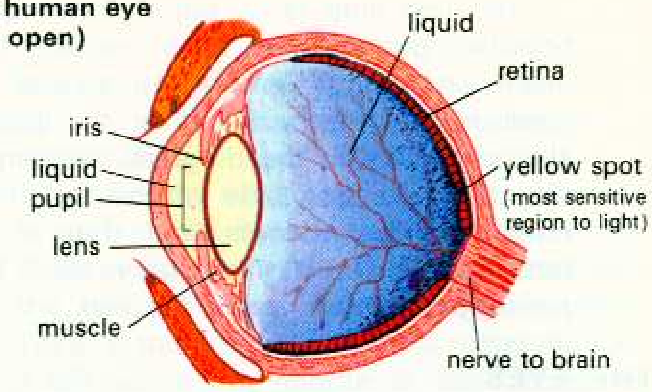
PARTS OF THE EYE

Look at your eyes in the mirror. You know the **eyebrows**, the **eyelids** and the **eyelashes**. These parts prevent dirt from entering into the eyes.

The coloured part of the eye is called the **iris**. In the centre of the iris is a round black hole or opening. This opening is called the **pupil**.

Look at your eyes again. There is fluid in your eyes. This fluid is known as **tears**. Tears wash the eyes. Tears can also kill germs which enter the eye. If any dirt falls into the

The human eye (cut open)



eyes, the tears wash it out. What happens when something gets into your eyes?

Light enters the eyes through the pupils. You see things through the pupils. Look at the pupil of a cat in the presence of:

(*a*) bright light and

(*b*) dim light.

In bright light the pupil becomes small. In dim light the pupil becomes big. Your pupils too become small in bright light and big in dim light. The iris makes the pupil smaller or bigger.

You can only see a small part of your eyes. Each eye is like a ball and is called the **eyeball**. The eyeball fits into a bony cavity in the face. Look at the picture of the eyeball. If you want to know what is inside the eyeball, it must be cut open.

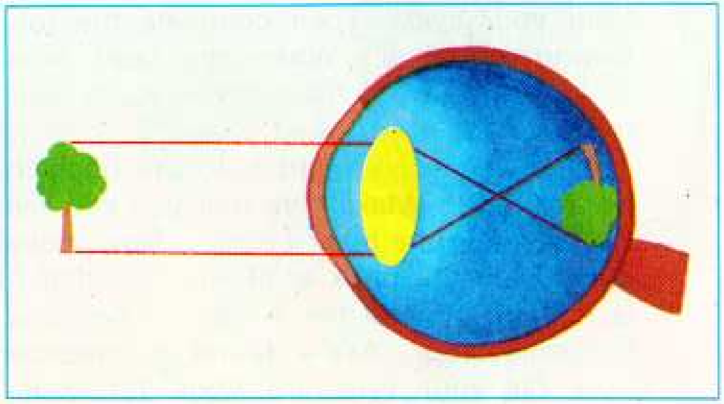
Look at the picture showing an eyeball which has been cut. Behind the pupil is a **lens**. There is a space between the pupil and the lens.

This space is filled with a liquid. Behind the lens there is a big space. This space is also filled with a liquid. The inside wall of the eyeball is called the **retina**. The retina is connected to the brain by **nerves**. When an image falls on the retina, a message is sent at once by the nerves to the brain. This is how a person sees things.

HOW THE EYES WORK

You look at a tree. Light from the tree enters the eye through the pupil. The light passes through the lens and falls on the retina. The image of the tree is formed on the retina. The image is upside down. A message about the image is sent to the brain by the nerves. The brain turns the image the right way up and you think, 'I see a tree.'

To show how the eyes work



Your eyes can see near objects. They can also see far objects. When your eyes see near objects each lens becomes fatter and shorter. This is caused by the contraction of the muscles of the eye. When your eyes see far objects, the muscles relax and each lens becomes thinner and longer.

Things to Do

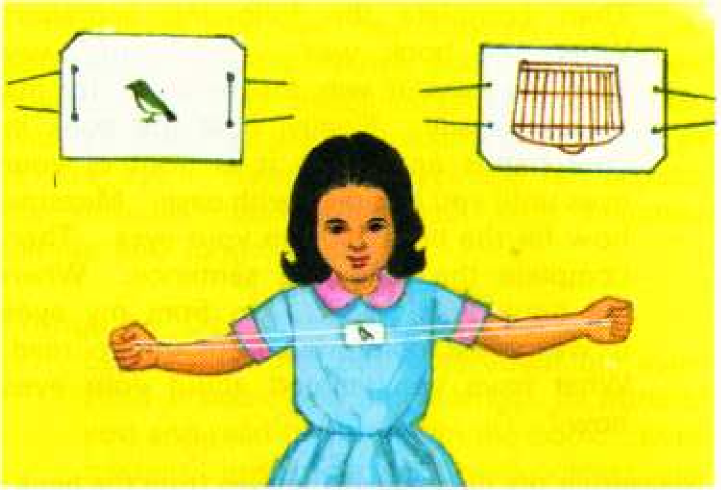
(i) Let us now find out more about our eyes. Hold a book one arm's length in front of you and read the words in the book. Keep reading, but bring the book closer and closer to your eyes. As you do this, can you feel that something is happening in your eyes?

At the point when you can no longer read the words in the book, stop and keep the book in that position. Ask a friend to measure how far the book is from your eyes. Then complete the following sentence: When the book was .... cm away from my eyes, it was too near for me to read easily.

Next, ask a friend to hold the book in front of you. Make sure that you can see the words in the book clearly. Now move away from the book until you find that it is difficult to read the words. When this happens, stop. Ask a friend to measure how far your eyes are from the book.

Then complete the following sentence: When the book was .... cm away from my eyes, it was too far away for me to read easily. Finally, hold the book in your hands and move it in front of your eyes until you can read with ease. Measure how far the book is from your eyes. Then complete the following sentence: When the book was .... cm from my eyes it was most comfortable for me to read. What have you learned about your eyes now?

Measuring the distance of the eyes from the book



How to spin a rectangular cardboard

(ii) We can also find out another interesting fact about our eyes. Cut out a rectangular cardboard about 10 cm by 5 cm. Punch two holes at each end of the cardboard. Draw a picture of a bird on one side. On the other side draw a bird cage up-side down. Thread strings into the holes as shown. Now use the strings to spin the cardboard quickly. Do you see one picture or two pictures when the card-board is spinning quickly? Do you see the bird inside the cage? When the cardboard is spinning slowly how many pictures can you see? When images are formed quickly in your eyes you cannot see each one separately from the other.

MAKING PICTURES WITH A LENS

We have learned that an image is formed on the retina when light passes from an object through the lens of the eye. In the same way we can get an image on a screen when light from an object passes through a lens.

Things to Do

Place a lighted candle on the table. Place a white screen in front of the candle. The screen should be about 40 to 50 cm from the candle. Now put a lens against the screen. Move the lens slowly towards the candle. Stop moving the lens when a picture or image is seen on the screen. What can you say about the image on the screen? Is it large or small? Is it upside down? The image should be small and upside down.

How an image is formed by a lens

Now continue to move the lens slowly towards the candle until another image is seen on the screen. What can you say about the image? Is it larger than the first one? Is it still upside down? Complete the following sentences:

(*a*) When the lens is nearer the screen, the image is upside down and ....

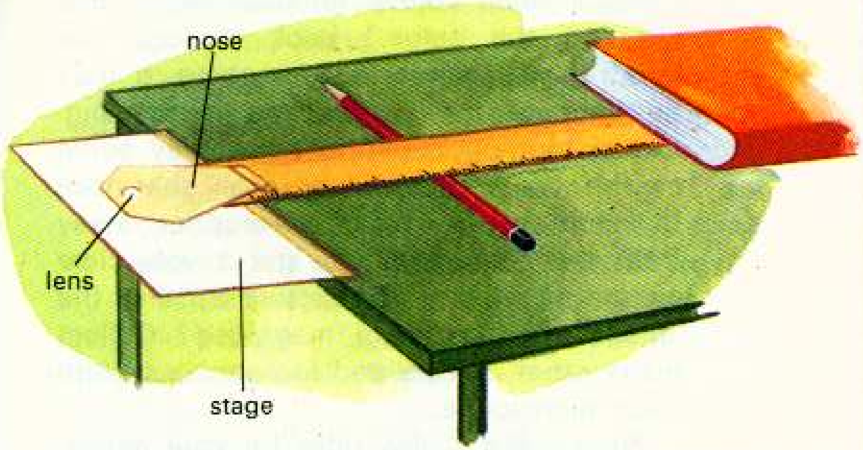
(*b*) When the lens is farther away from the screen, the image is upside down and ....

A WATER DROP MICROSCOPE

Take a magnifying glass and place it near the words of this book. What do you see through the glass? Do the words become bigger? If they appear to be bigger we say that they are **magnified**. A microscope also magnifies objects. Let's make a simple microscope.

Things to Do

(i) Take a piece of stiff paper about 8 cm square. Punch a hole in the paper with a file punch. Cut the paper as shown in the diagram. Use adhesive tape to stick the end of the paper which has no hole to a ruler. The paper is now known as the 'nose' of the microscope. The hole is called the 'lens-hole'.



A water drop microscope

Next, take another piece of stiff paper slightly bigger than the first one. Use an adhesive tape to stick one side of the paper to the edge of the desk. This paper is now known as the 'stage' of the microscope.

Place one end of the ruler under a heavy book and see that the other end holding the nose lies above the stage. Insert a pencil under the ruler. Dip your finger in water and pick up a drop of water. Put the water drop in the lens-hole. The water in the lens-hole becomes the 'lens' of the microscope. The microscope itself is called a 'water drop microscope'.

(ii) Let us use our water drop microscope.

Place a small object, for example a dead ant, on the stage. Look through the lens. If you cannot see anything, it may be because the water drop is too big. Use a blotting paper to take away some of the water. Lower or raise the nose by shifting the pencil nearer or away from the book until you get a very clear picture of the ant. The picture is called the 'image'. Is the image magnified? Collect many other objects and look at them with your microscope.

Now make a new nose for your microscope. Make three lens-holes of different sizes in the new nose. Place water drops in the three holes and look at an object with each new lens. Are all the images the same? Which lens gives the clearest image?

A PIN-HOLE CAMERA

An image can also be obtained without using a lens. You can get this image by making a pin-hole camera.

Things to Do

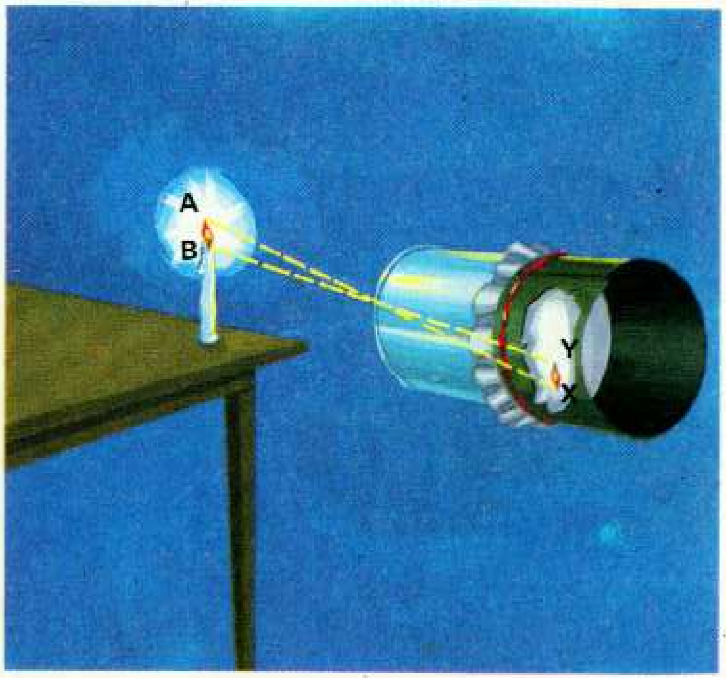
All you need is an empty cigarette tin, a piece of dark paper and a piece of tracing paper. Make a hole at the bottom of the tin with a very small nail. Remove the lid from the top of the tin. Put the tracing

paper over this end and hold it in place with an elastic band. Roll the dark sheet of paper over the tin as shown in the picture. What you have now is a pin-hole camera.

Light a candle and place it on the table. Place your pin-hole camera in front of the candle. What do you see on the tracing paper? Is the image upside down?

Light travels in straight lines. Look at the picture. Light from A passes through the hole and strikes at X on the tracing

A pin-hole camera



paper. Light from B strikes at Y. Light from all other points between A and B reaches the tracing paper between X and Y in a similar way. Therefore the image formed on the tracing paper is upside down. Now do you know why the image formed on the retina of your eye is upside down?

Use your pin-hole camera to get images of trees, buildings, lamp posts, and other objects outside the classroom. What can you say about the images obtained with a pin-hole camera?